PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING

To:
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NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing *(day/month/year)* 07 FEBRUARY 2005 (07.02.2005)	
Applicant's or agent's file reference P02E8010/PCT	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/months/year)*
PCT/KR2002/002214	**26 NOVEMBER 2002 (26.11.2002)**	26 OCTOBER 2002 (26.10.2002)

Applicant

Electronics and Telecommunications Research Institute et al

1. The applicant is hereby notified that International Preliminary Examining Authority transmits here with the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report(but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details in the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/KR Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer COMMISSIONER Telephone No. 82-42-481-5198

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Artcle 36 and Rule 70)

Applicant's or agent's file reference P02E8010/PCT	FOR FURTHER ACTION	SeeNotificationofTransmittalofInternationalPreliminary Examination Report (Form PCT/IPEA/416)
International application No. **PCT/KR2002/002214**	International filing date *(day/month/year)* **26 NOVEMBER 2002 (26.11.2002)**	Priority date *(day/month/year)* 26 OCTOBER 2002 (26.10.2002)

International Patent Classification (IPC) or national classification and IPC

IPC7 H04J 11/00

Applicant

Electronics and Telecommunications Research Institute et al

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 9 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

Date of submission of the demamd	Date of completion of this report
23 MARCH 2004 (23.03.2004)	07 FEBRUARY 2005 (07.02.2005)
Name and mailing address of the IPEA/KR Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer PARK, Sung Ho Telephone No. 82-42-481-5724

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International aplication No.
PCT/KR2002/002214

I. Basis of the report

1. With regard to the elements of the international application:*

☐ the international application as originally filed

☒ the description:
pages 1 -52, as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the claims:
pages ______, as originally filed
pages ______, as amended (together with any statment) under Article 19
pages ______, filed with the demand
pages 53 - 61, filed with the letter of Feb. 2, 2005

☒ the drawings:
pages 1/46 - 46/46, as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☐ the sequence listing part of the description:
pages ______, as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language English which is

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☒ the language of publication of the international application(under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination(under Rules 55.2 and/ or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained inthe international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disc losure in the international applicationas as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☐ the description, pages ______

☒ the claims, Nos. 9

☐ the drawings, sheets ______

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box(Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed." and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION

International aplication No.

PCT/KR2002/002214

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1 - 31	YES
	Claims	None	NO
Inventive step (IS)	Claims	1 - 31	YES
	Claims	None	NO
Industrial applicability (IA)	Claims	1 - 31	YES
	Claims	None	NO

2. Citations and explanations (Rule 70.7)

1) Inventive Step

The following documents were referred to in the International Search Report(ISR):

D1: Computing partial DFT for comb spectrum evaluation
Shousheng He; Torkelson, M.; Signal Processing Letters, IEEE , Volume: 3 Issue: 6 , June 1996; Page(s): 173 -175

D2: VLSI computation of the partial DFT for (de)modulation in multi-channel OFDM system
Shousheng He; Torkelson, M.;
Personal, Indoor and Mobile Radio Communications, 1995. PIMRC'95. 'Wireless: Merging onto the Information Superhighway'., Sixth IEEE International Symposium on ; Volume: 3 , 27-29 Sept. 1995.

The present invention relates to a method for providing frequency-hopping OFDMA using symbols of comb pattern, the method including the steps of: a) assigning frequency domain signal X(k) of comb pattern (comb symbol, k is frequency index) to modulated data sequence, the comb symbol comprising predetermined number of sub carriers (sub carrier group) which are placed with predetermined interval in the whole available frequency band; b) getting the comb symbol hopped for the comb symbol to have an independent frequency offset; and c) inverse fast fourier transforming the comb symbol to time domain signal x(n) (n is time index) and transmitting the signal.

On the other hand, D1 discloses a (de)modulation for orthogonal frequency division multiplexing-based (OFDM-based) multichannel communication system in fig.1-fig.3. The frequency shift technique has been applied to allow a modularized mixed-radix structure for the computation of comb spectrum with an initial component not starting from zero frequency point.

D2 discloses an efficient computation of partial DFT for comb spectrum evaluation in fig.2-fig.4.

*** To be continued at the page of the supplemental box ***

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International aplication No.

PCT/KR2002/002214

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of:

*** Continuation of the box V. ***

By the way, comparing the technical features of the amended claims 1 - 31 in the present invention with those of the prior art of D1, or D2 above, the technical features of D1 or D2 include only a part of the technical components of the amended claims 1 - 31 of the present invention.

Consequently, it would not be obvious to a person skilled in the art to make a method for providing frequency-hopping OFDMA using symbols of comb pattern of the amended claims 1 - 31 in the present invention by combining the technical features shown in D1 and D2.

The characterizing features of the amended claims 1 - 31 of the present invention are considered to involve an inventive step under PCT Article 33(3).

2) Novelty and Industrial Applicability.
The amended claims 1-31 in the present invention are considered to be novel and industrially applicable under PCT Article 33(2) and 33(4).

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IPEA/KR 02.02.2005.

What is claimed is:

1. A method for performing frequency hopping Orthogonal Frequency Division Multiple Accesses (OFDMA), comprising the steps of:

a) allocating frequency domain signals X(k) of a comb pattern to a modulated data sequence, X(k) being comb symbols and k being a frequency index;

b) performing frequency hopping so that the comb symbols could have an independent frequency offset; and

c) performing inverse Fast Fourier Transform (FFT) on the comb symbols to be transformed to time domain signals x(n) and transmitting the time domain signals x(n), n being a time index,

wherein the comb symbols formed of a predetermined number of sub-carriers, which is called a sub-carrier group, are positioned on an entire usable frequency band at predetermined intervals and the number of sub-carriers on the entire usable frequency is expressed as:

$$N = \sum_{l}^{N_C} N_{sl} = N_C * N_S, \quad (N_{sl} = N_s = Const.)$$

where N_C denotes the number of comb symbols that can be allocated in the entire usable frequency band;

N_{sl} denotes the number of sub-carriers within an i^th comb symbol, the size of the i^th comb symbol, or the size of a sub-carrier group constituting the i^th comb symbol, and

$$X_{N_C,l,q}(k) = \begin{cases} \neq 0, k = p_l N_C + q_l \\ = 0, \ Otherwise \end{cases}$$

$$\begin{cases} p_l = 0,1,\ldots,N_{sl}-1 \\ q_l = 0,1,\ldots,N_C-1 \end{cases}$$; and

wherein, in the step b), frequency hopping is performed on comb symbols $X_{a,b}(k)$ allocated to the mobile station in the cell according to a frequency indicator function $Y_{a,b}(k;l)$, which is a frequency hopping pattern and

expressed as:

$$Y_{a,b}(k;l) = X_{a,b}((k+P(l)) \bmod N)$$

where P(l) (0 ≤ P(l) ≤ N) is a frequency hopping pattern of comb symbols within a cell in a time slot l; and N denotes the entire number of sub-carriers.

2. The method as recited in claim 1, wherein if there are N sub-carriers and N is a power of 2 ($N=2^n$), n being an integer that is not negative, the step a) includes the steps of:

a1) forming a comb symbol tree T_{2^n} which is formed of 1 to 2^n sub-carriers, wherein a comb symbol $X_{1,0}$ having 2^n sub-carriers is a parent node and a comb symbol $X_{2^a,b}$ having 2^{n-a} sub-carriers and having a frequency offset b includes $X_{2^{a-1},b}$ and $X_{2^{a-1},b+2^a}$ as child nodes, each having 2^{n-a-1} sub-carriers and having a frequency offset b and $b+2^a$, respectively, and a comb symbol having one sub-carrier is an end node; and

a2) allocating comb symbols having appropriate size for a transmission rate requested by mobile station to the mobile station and preventing collision between the comb symbols by not allocating comb symbols corresponding to child nodes of the comb symbols in the tree T_{2^n} to the other mobile stations in the cell to which the mobile station belongs, until the comb symbols having appropriate size are released from the allocation.

3. The method as recited in claim 2, wherein if the number of sub-carriers that can carry data is not a power of 2 due to the presence of null carriers among N sub-carriers in the entire usable frequency band, N being a power of 2 ($N=2^n$, n being an integer that is not negative), part of the data corresponding to the null carriers is punctured in the step a).

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4. The method as recited in claim 2, wherein if the number of sub-carriers that can carry data is not a power of 2 due to the presence of null carriers among N sub-carriers in the entire usable frequency band, N being a power of 2 ($N=2^n$, n being an integer that is not negative), any loss in the data transmission rate is prevented by inserting null data into the data at positions corresponding to the null carriers and allocating sub-carriers that are not null carriers to the data corresponding to the null carriers in the step a).

5. The method as recited in claim 1, wherein if there are N sub-carriers in the entire usable frequency band (2^{n-1} < N < 2^n), the step a) includes the steps of:

a3) forming a comb symbol sub-tree $T_{2^{n'}}$ which is formed of 1 to $2^{n'}$ sub-carriers, wherein a comb symbol $X_{1,0}$ having $2^{n'}$ sub-carriers is a parent node and a comb symbol $X_{2^a,b}$ having $2^{n'-a}$ sub-carriers and having a frequency offset b includes $X_{2^{a+1},b}$ and $X_{2^{a+1},b+2^a}$ as child nodes, each having $2^{n'-a-1}$ sub-carriers and having a frequency offset b and b+2^a, respectively, and a comb symbol having one sub-carrier is an end node;

a4) forming a multiple-tree having a_i comb symbol sub-trees and a total of N sub-carriers by performing the step a3) with respect to each i; and

a5) selecting comb symbols having appropriate size for a transmission rate requested by a mobile station from one sub-tree out of the multiple-tree and allocating the comb symbols to the mobile station, and preventing collision between the comb symbols by not collecting comb symbols corresponding to child nodes of the comb symbols in the selected sub-tree to the other mobile stations in the cell to which the mobile station belongs, until the comb symbols having appropriate size are released from the allocation,

wherein comb symbols of the multiple-tree formed of a plurality of sub-trees are re-defined as:

AMENDED SHEET (ART. 34)

Clear Version

$$X_{st,N_c,q}(k)\begin{cases}\neq 0, k = pN_c + q + K_{st}\\ = 0, otherwise\end{cases}$$

where st denotes a sub-tree index;

K_{st} denotes a beginning frequency index of a sub-tree;

$p=0,1,\cdots,(N_{st}/N_c)-1$, N_{st} being the number of sub-carriers of a sub-tree; and

$q=0,1,\cdots,N_c-1$.

6. The method as recited in claim 5, wherein, in the step a5), the comb symbols having appropriate size for a transmission rate requested by the mobile terminal are selected preferentially from a sub-tree having no comb symbol allocated among the sub-trees of the multiple-tree.

7. The method as recited in claim 1, wherein the step a) includes the steps of:

a6) dividing N sub-carriers existing in the entire usable frequency band into M sub-bands;

a7) forming a comb symbol sub-tree $T_{2'}$ which is formed of 1 to $2^{n'}$ sub-carriers, wherein a comb symbol $X_{1,0}$ having $2^{n'}$ sub-carriers is a root node and a comb symbol $X_{2^a,b}$ having $2^{n'-a}$ sub-carriers and having a frequency offset b includes $X_{2^{a-1},b}$ and $X_{2^{a-1},b+2^a}$ as child nodes, each having $2^{n'-a-1}$ sub-carriers and having a frequency offset b and $b+2^a$, respectively, and a comb symbol having one sub-carrier is an end node;

a8) forming a multiple-tree having M comb symbol sub-trees and a total of N sub-carriers by performing the step a7) with respect to each sub-band; and

a9) selecting the comb symbols having appropriate size for a transmission rate requested by a mobile station from one sub-tree out of the multiple-tree and allocating the comb symbols to the mobile station, and preventing collision between the comb symbols by not allocating comb symbols corresponding to child nodes of the comb symbols having appropriate size in the selected sub-tree to the

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Clear Version

other mobile stations in the cell to which the mobile station belongs, until the comb symbols having appropriate size are released from the allocation,

wherein comb symbols of the multiple-tree formed of M sub-trees are re-defined as:

$$X_{st,N_c,q}(k)\begin{cases}\neq 0, k = pN_c+q+K_{st}\\ =0, otherwise\end{cases}$$

where st denotes a sub-tree index;

K_{st} denotes a beginning frequency index of a sub-tree;

$p=0,1,\cdots,(N_{st}/N_c)-1$, N_{st} being the number of sub-carriers of a sub-tree; and

$q=0,1,\cdots,N_c-1$.

8. The method as recited in claim 7, wherein, in the step b), frequency hopping is performed on the comb symbols on a basis of a sub-tree to which the comb symbols allocated to the mobile station belong.

9. The method as recited in claim 1, wherein, in the step b), the comb symbols perform frequency hopping to comb symbols having the same size but different frequency offset.

10. (Original) The method as recited in claim 1, wherein, in the step b), the comb symbols perform frequency hopping so that all comb symbols have a frequency hopping pattern randomly.

11. (Original) The method as recited in claim 1, wherein, in the step b), the comb symbols perform frequency hopping so that the same frequency hopping pattern is provided to all mobile stations within the same cell.

12. (Original) The method as recited in claim 11, wherein, in the step b), the comb symbols perform frequency hopping so that mobile stations between different cells can

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have different frequency hopping patterns.

13. (Original) The method as recited in claim 11, wherein, in the step b), the comb symbols perform frequency hopping so as to have different frequency hopping intervals between cells.

14. (Original) The method as recited in claim 11, wherein, in the step b), the comb symbols perform frequency hopping so that the direction of the frequency hopping could be different according to each cell.

15. (Original) The method as recited in claim 1, wherein if a comb symbol is to be allocated additionally upon a request of a mobile station, a comb symbol formed of a sub-carrier group that is adjacent to the sub-carrier group of the currently allocated comb symbol is allocated additionally.

16. (Original) The method as recited in claim 15, wherein if the additional comb symbol is formed of a sub-carrier group selected from sub-carrier groups each having the same size as the sub-carrier group constituting the currently allocated comb symbol.

17. (Original) The method as recited in claim 15, wherein, in the step b), the additionally allocated comb symbol performs frequency hopping among the sub-carrier groups each having the same size as the sub-carrier group constituting the currently allocated comb symbol.

18. (Original) The method as recited in claim 15, wherein, by utilizing a summation of sub-carrier groups constituting the allocated comb symbols as a minimum unit for frequency hopping, in the step b), the frequency hopping is performed into a comb symbol formed of a sub-carrier group that corresponds to a number obtained from:

Clear Version

$$G=(g_n+P(l)\times i)\bmod N_c$$

where G denotes a group number in a time slot l;
$P(l)$ denotes a frequency hopping pattern function;
i denotes the number of allocated groups; and
g_n denotes a group number in the initial time slot, and

wherein, when a comb symbol is allocated additionally, the summation of the sub-carrier groups is the same as the summation of all the sub-carrier groups constituting the initially allocated comb symbol and the additionally allocated comb symbol.

19. (Original) The method as recited in claim 15, wherein, in the step b), the sub-carrier group constituting the initially allocated comb symbol is used as a minimum unit for frequency hopping and an allocated comb symbol performs frequency hopping.

20. (Original) The method as recited in claim 1, wherein inverse Fast Fourier Transform is performed based on Decimation In Frequency (DIF) algorithm in the step c), and the step c) includes a step of:

c1) inputting the frequency domain signals X(k) by mapping input addresses of a fast Fourier Transform (FFT) unit to the frequency indexes k sequentially.

21. (Original) The method as recited in claim 20, wherein the step c) further includes a step of:

c2) not performing butterfly computation, if 0 is inputted to all the input ends of a butterfly that forms the IFFT unit.

22. (Original) The method as recited in claim 1, wherein IFFT is performed based on Decimation In Time (DIT) algorithm and the step c) includes a step of:

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c3) inputting the frequency domain signals X(k) by mapping bit-reversed values of the input addresses of the IFFT unit to the frequency indexes k.

23. (Original) The method as recited in claim 22, wherein the step c) further includes a step of:

c4) not performing butterfly computation, if 0 is inputted to all the input ends of a butterfly that forms the IFFT unit.

24. (Original) The method as recited in claim 1, further including the steps of:

d) receiving time domain signals y(n) that corresponds to the comb symbols transmitted in the step c);

e) restoring the time domain signals y(n) into a frequency offset established initially; and

f) demodulating the modulated data sequence by performing FFT on the time domain signals y(n) to be transformed into frequency domain signals Y(k), k being a frequency index.

25. (Original) The method as recited in claim 24, wherein FFT is performed based on the DIF algorithm in the step f), and the step f) includes a step of:

f1) outputting the frequency domain signals Y(k) by mapping bit-reversed values of output address of the FFT unit to the frequency indexes k.

26. (Original) The method as recited in claim 25, wherein the step f) further includes a step of:

f2) controlling the butterfly, a part of the FFT unit, to perform or not perform computation according to the frequency domain signals Y(k) outputted from the FFT unit.

27. (Original) The method as recited in claim 24, wherein FFT is performed based on DIT algorithm in the step f), and the step f) includes a step of:

f3) outputting the frequency domain signals Y(k) by mapping output addresses of the FFT unit and the frequency indexes k sequentially.

28. (Original) The method as recited in claim 27, wherein the step f) includes a step of:

f4) controlling the butterfly, a part of the FFT unit, to perform or not perform computation according to the frequency domain signals Y(k) outputted from the FFT unit.

29. (Original) The method as recited in claim 1, wherein the data sequence corresponds to a pilot signal or a control signal.

30. (Original) The method as recited in claim 29, wherein the comb symbol performs frequency hopping to maintain a predetermined frequency offset including 0 in the step b).

31. (Original) The method as recited in claim 30, wherein, in the step a), the top priority order is given to sub-carrier groups including 0 addresses from input addresses of the IFFT unit and output addresses of the FFT unit and the next priority is given to sub-carrier groups neighboring the sub-carrier groups having priority, and comb symbols are allocated to the pilot signal or the control signal according to the priority order.